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ABSTRACT

The purpose of this study was to write a computer program that would not only output a color pattern weave to a cathode ray tube (CRT), but would also analyze a painted design and output a printed diagram that would show how to set up a loom in order to produce the woven design. The first of seven chapters describes the problem and the intent of the study, while the second clarifies the basic process of drafting through a description of conventional drafting methods. Computer aided drafting of a textile design is briefly explained in the third chapter, which also describes the development of a program that defines a traditional pattern draft as a matrix and outputs it to a color monitor and a line printer. It is noted that this program is closely modeled after the methods used to generate a pattern weave draft by hand, and that it will not only produce a diagram, but translate it into a texture form for mapping onto a two or three dimensional surface. Some of the problems encountered in programing the texture mapping for this study, which is currently limited to two dimensional surfaces, are discussed in the fourth chapter, and advantages and disadvantages of designing textile pattern weaves by computer program are considered in the fifth. A discussion of educational and industrial applications of computer-aided textile design is presented in the sixth chapter, and the final chapter briefly considers future possibilities for the use of computers as visual design tools for both education and industry. The text is illustrated by 24 figures and a glossary is provided, as well a 22-item bibliography and 13 references. (Author/MES)

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COMPUTER REPRESENTATION OF FABRIC PATTERN WEAVES AS
WOVEN FABRIC SAMPLES AND TEXTURE MAPS
FOR EDUCATIONAL AND INDUSTRIAL APPLICATIONS

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A Thesis

Presented in Partial Fulfillment of the Requirements
for the Degree Master of Arts

by

Judith Rush Murtha, BFA

The Ohio State University
1983

Approved by

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THESIS ABSTRACT

THE OHIO STATE UNIVERSITY
GRADUATE SCHOOL

NAME: Judith Rush Murtha

QUARTER/YEAR: Spring 1983

DEPARTMENT: Art Education

DEGREE: Masters of Arts

TITLE: Computer Representation of Fabric Pattern Weaves as Woven
Fabric Samples and Texture Maps for Educational and Industrial Appli-
cations

This study presents an overview of computer generated fabric pattern weaves and the techniques involved in creating a computer program that will generate a pattern weave. The objectives, problems and solutions to the creation of fabric pattern weaves as a computer generated texture is outlined and discussed as well as for mapping the textures onto computer generated two and three dimensional images. Implications for educational and industrial applications are discussed. Future possibilities in research and industrial applications are entertained and explored.

Thomas E. Linahan

Advisor's signature

This thesis is dedicated to Jim and to my fetus with the
appreciation that he (or she) has not arrived before
due (June 7).

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CHAPTER 1

Introduction

My initial goal as a graduate student in the field of art education was to examine the design of large wall hangings through the use of the computer. I wanted to design a system to previsualize a three dimensional textile piece as it would appear in reality. I wanted this system to be able to simulate the tactile qualities of the woven fabric. Conventional design planning media for textile art (watercolors, paints, paper design, etc.) do not easily simulate this textural effect. Qualities such as draping and the three dimensionality of the individual yarns prevent the designer from previsualizing the finished piece. It was my goal to produce such a system to better learn to previsualize textile designs before I began to weave.

Initially my research involved generating three dimensional cylinders that could be interlaced to look like a woven fabric. As I generated these cylinders on the computer, I learned that the computer displayed these cylinders in a very rigid form, nothing like the soft, flexible qualities of yarn and fiber. The interlacing of each cylinder into a woven fabric required an innumerable amount of cylinders, each bent in a slightly different manner. This method required too many hours of creating shaped cylinders to be anything close to an effective means of designing fiber art pieces.

The ongoing research in the area of texture mapping at the Computer Graphics Research Group (CGRG) at the Ohio State University and an article by Paul Heiser on a weaving simulator for apple microcomputers[5] led me in the direction of generating two dimensional pattern weaves.

Computers and weaving have much in common. Computer technology is based on the bit. A circuit that can be either turned on or off. Weaving is designed so a yarn is shown on the surface of the fabric or not. A draft of a weaving pattern demonstrates this theory much more graphically (figure 1). A point on a grid is either plotted or not depending on the relationships of the treadle sequence, treadle tieup, and the draw through the harnesses. A computer performs a similar function. A circuit is either opened or closed and an electrical impulse is allowed to flow or not flow through that circuit. Similarly, a point can be plotted onto a display device by directing the flow of the electrical impulses to a specific point on the screen.

I decided to employ the similarities of computer graphics and weaving to produce simple and complex pattern weaves. My intent was to write a program that would not only output a color pattern weave to a Cathode Ray Tube (CRT) (a device similar in appearance to a television screen that permits the display of characters and graphic designs) but would also analyze a painted design and output a printed diagram. The printed diagram or draft would show how to set up a loom in order to produce the woven design.

My experiences in textile design for industry has taught me that drafting even the simplest patterns by hand is labor intensive. Computer programs (a set of instructions given to the computer to perform certain tasks) have the ability to generate arrays or matrices such as the two dimensional matrices that are used to represent pattern weave drafts. Computers are also faster than humans at processing array information and can more easily manipulate matrix data into various forms.

Based on these experiences and concepts, I wrote a program that would output a woven textile design to a CRT. It was my hope that later development would bring about more sophisticated uses for pattern weaves. I also wanted to use this program as a stepping stone to a more complex routine that would analyze painted designs for three dimensional weavings. I soon found out, however, that my lack of training in computer science limited my development of a more sophisticated program. I found that writing the initial program that generated pattern weaves in color was quite a challenge.

The following text describes, in more detail, the processes I used in generating fabric pattern weaves. Conventional drafting methods are presented as a means to clarify the basic process of drafting. A description of my program and how it generates pattern weaves and the process of texture mapping is discussed. The text outlines how I generated pattern weaves. Finally I explore the future possibilities for textile designing and how computers may be used as visual design tools for education and industry.

CHAPTER 2

Conventional Drafting Methods in Textile Design

A woven textile is the interlacing of two sets of yarns, usually at right angles, creating a solid piece of fabric. The pattern of the cloth is the plan or order in which the yarns are interlaced. [1] This form of pattern weaving uses the weaving draft to its best advantage. A sketch of the pattern is made to enable correct analysis of the weave, determine how the loom must be set up for weaving, and in the case of the handweaver, facilitate the memorization of a treadling sequence. [4] Conventional methods require that the designer hand color large areas of graph paper. The process involved in this drafting method is described below.

The pattern in which the warp yarns are drawn through the harnesses is set up horizontally across the top of a piece of graph paper. The treadle tieup and treadle sequence is set up along the vertical side of the page. Information is supplied as to which harnesses are to be raised or lowered by diagraming which harnesses are tied to which treadles. The drafter follows these clues to determine which warp yarns will be used to fill in specific grid locations on the paper with the color corresponding to a specific warp yarn. This is done for each row of the design (figure 1). Size will further complicate the design since it must be drawn as large as a repeat demands. For example, a medium weight fabric measures twelve inches by twelve inches. There are twenty four ends along the

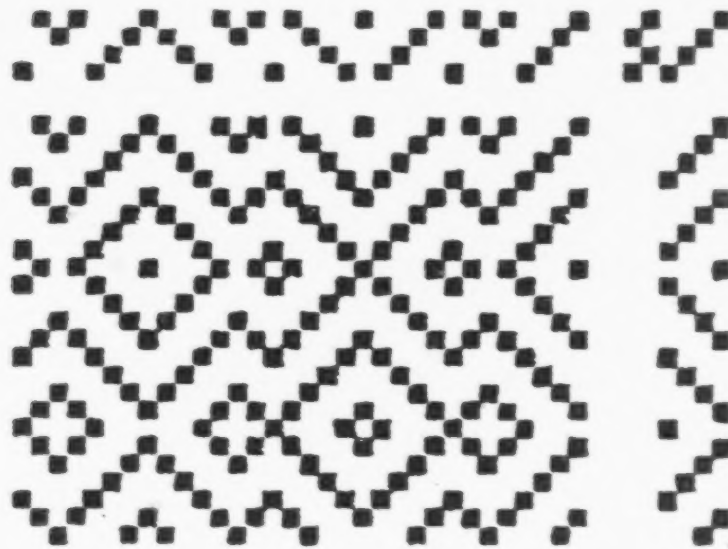


figure 1
hand drawn draft

horizontal edge or the warp of the fabric and twenty four end along the vertical edge or the weft of the fabric. This produces a grid of 288 squares by 288 squares or a total of 82944 squares. Each square must be colored with the corresponding warp color according to the designated harness and treadle sequence. A slight mistake may substantially change the characteristics of the design.

As one can see, the process of designing a woven fabric on graph paper is labor intensive. Revisions requiring only minor changes become a monumental task. All the necessary decisions concerning the design cannot possibly be made until the drafting has begun. For example, color changes substantially alter the design or pattern. Consequently, the creative process is restricted by the need to draft

and redraft simple to complex patterns in order to derive an aesthetically pleasing design.

Graph paper that conforms to the proportions of ends per inch in the warp to the ends per inch in the weft is necessary to accurately draft the pattern. This is not to say that a fabric that uses 128 ends per inch in the warp and 64 ends per inch in the weft must be designed on a piece of graph paper with 128 x 64 squares per inch of the paper. Rather the proportion of the squares in the graph paper must be two to one. The length of the square must be two times the width. It is often difficult to find the necessary types of graph papers in a paper size required to complete a pattern repeat. The solution to this proportion problem must be a compromise. Without using the proper size graph paper, the woven pattern will appear different than the draft had indicated (figure 2).

Patterns having long float threads pose another display problem. The pattern must be secured with an alternating tabby weave (a simple one over one under weave) to prevent the final fabric from catching on buttons, hooks, etc. and pulling the fabric apart. To include the alternating tabby weaves into the draft makes it difficult to analyze the final pattern (figure 3). Excluding the tabby from the draft poses an additional risk of omitting it in the weaving process. Textile designers designing for industry cannot omit the tabby, as it is transferred literally, as it appears in the draft, to the production loom.

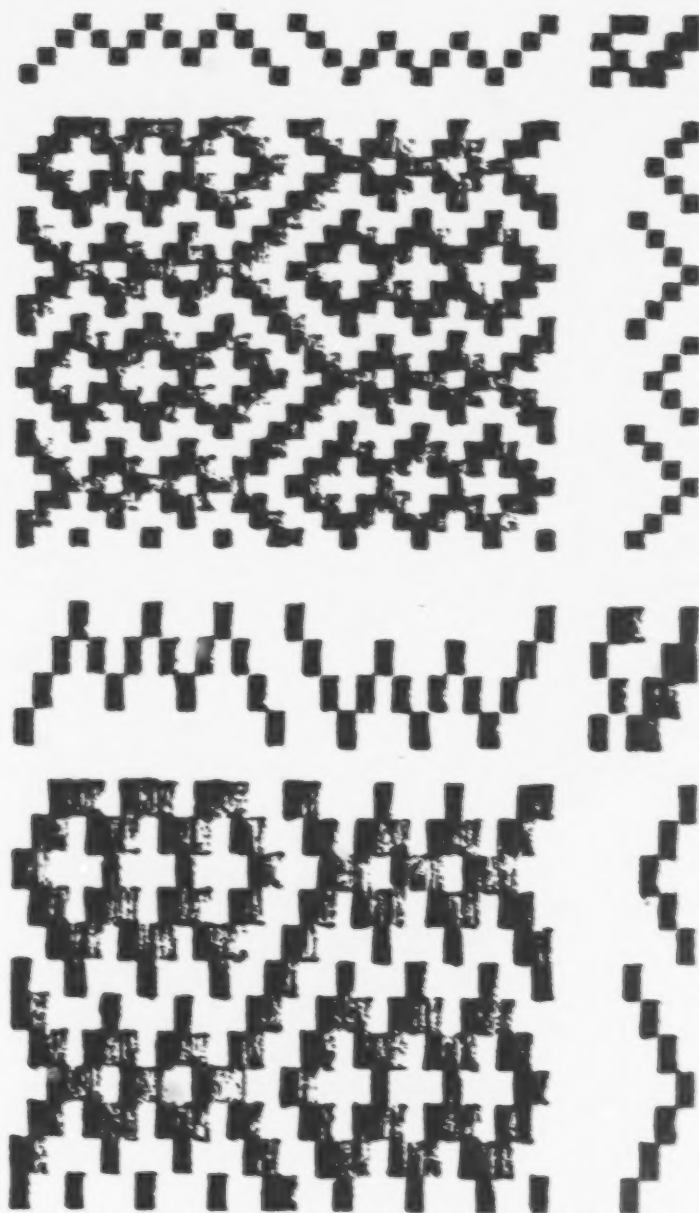


figure 2
two renditions of a drafted design using
two different sizes of graph paper.

Additional problems are encountered when attempting to recreate

a color to match that of the yarn. If the yarn is dyed to match the designers rendition, color matching may be less of a problem. A well skilled dyer may be able to determine how specific fibers will dye. Highly controlled conditions (temperatures, mordants, time in dye bath, etc) are critical in predicting with accuracy what color dyes-tuffs will be needed to produce the desired yarn color. Dye batches in industrial settings are highly controlled. Ongoing scientific research is currently done for every dyestuff and mordant and their effects on the fibers they dye. Attention to the precise temperatures needed for the dying process is needed as well. Careful records are kept so that a specific color may be recreated on demand. However, even under the most highly controlled situations, no two

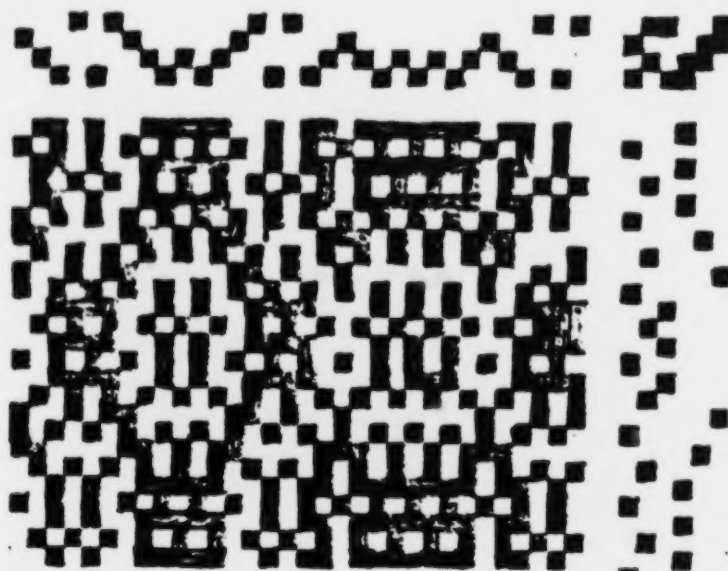


figure 3
draft with alternating tabby weave

batches of dyed fibers are ever identical.

In many instances, designer's are required to use yarns that have been previously dyed. Reliable representations of the drafted pattern also rely on accurate color descriptions. Dependable color media for rendering drafts may limit the designer's choices in colors. The time and patience required to mix the necessary amounts of paint to cover an entire design essentially eliminates paint as an economical medium. The paint must be kept from drying out during the long painting process. The result is often tedium and eyestrain. Alternatives, such as colored pencils and felt tipped markers, are available. However, matching and mixing colors accurately is still a difficult task with these alternative media.



figure 4
computer designed draft with tabby included

True color and graphic representation is important in a drafted design. It provides the first clue of the visual and tactile possibilities of the resulting fabric.

CHAPTER 3

Computer Aided Drafting of a Woven Textile Design

It is not unusual that a correlation between computers and weaving should be investigated. It was, after all, the invention of the jacquard loom that inspired the first implementation of computers. Between 1833 and 1840, Charles Babbage designed the Analytic Engine with inspiration he received from the recent invention of the jacquard loom. In the late nineteenth century, Herman Hollerith developed a punch card system for analyzing census data. These cards became the original IBM punch cards. [6] Many such applications have been developed in the past 150 years. Computer technology has almost eliminated cards as a means of entering information into the computer. We now think of computers on their most basic level, the "bit". A comparison can be drawn back to the original predecessor of the computer, the jacquard loom and current computer technology. Instead of developing the technology to serve the weaver, we can now think in terms of having the weaver develop computer technology to suit present needs.

Like a computer, a draft of a woven textile design utilizes the on/off theory. A character is either printed or not. A yarn is hidden or exposed. It closely resembles the way in which the raster display produces an image. Pixels are illuminated at a specific location on a grid. Squares are colored in the conventional method of drafting on graph paper.

As part of my research, I developed a computer program that defines a traditional pattern draft as a matrix and outputs it to a color monitor and a line printer. This program was developed with the assistance of Paul MacDougal, a researcher at CGRG, who has a special interest in the area of texture mapping. The computer program employs the current state-of-the-art in mapping texture onto two and three dimensional computer generated objects. My assumption is that since computers are substantially faster than human beings in generating mathematical and geometrically produced information, the drafting of a patterns can be more quickly produced through the use of computers. Minor alterations become as simple as key strokes on a computer terminal. Serendipity can be exploited, creative processes and aesthetic decisions can be allowed to be made freely without being hindered by the tedious filling in of squares. Colors and textures can be explored. Any number of shapes and designs can be used. Designs can be stored on secondary storage devices such as disk drives or tape drives. They can be recalled and modified at any time. Several examples of different treadlings for a single draw through the harnesses can be produced in moments (figure 5). A simulation of the overall feeling provided by the actual woven fabric can be generated before it is woven by mapping it onto a three dimensional objects.

Although woven fabrics have been simulated on less expensive microcomputers with effective results[2], I have used a VAX 11/780 with 2 megabytes of memory to program these textures thus allowing

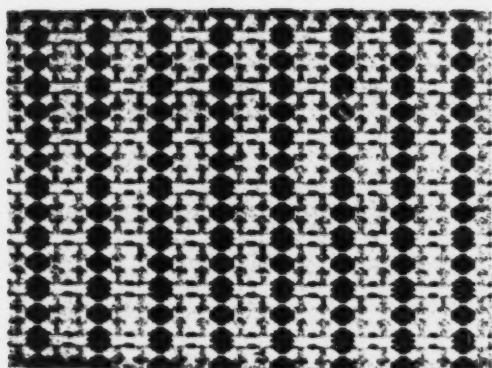


figure 5
two examples of one harnesses draft
with two different treadling sequences

for a broader range of images. The increased memory provides for a faster response time and an increased repertoire of computer operations.

Execution of the program requires an input file. A colored texture is output to the frame buffer and a skeleton draft of one repeat of the pattern is produced to a printable file. A 128 by 128 matrix is used for storing the color and location of each pixel in the color map (The 128 x 128 matrix size was imposed by restrictions of support software in texture mapping supplied by Paul MacDougal and the Computer Graphics Research Group.). Due to texture size restrictions, one repeat of the sample produced by my program must be no larger than 128 ends in the warp and 128 ends in the weft. Texture can essentially be lifted off the CRT and mapped onto an object.

I also set a limit of thirty for the number of treadles allowed by the user. While this restriction allows one to produce intricate pattern weaves, it prohibits jacquard designing as an option. While I wanted one to be able to produce intricate pattern weaves, I wanted the patterns to be harness controlled as opposed to the heddle control that a jacquard loom provides.

Hardware devices also impose some size limits on the matrix used by my program. The Centronics 704 printer prints a maximum line of 132 characters per line. Setting a limit for printable characters in the skeleton draft to 128 avoids possible character wrap arounds to the next line. Thus one repeat of the sample plus the numbers of treadles used, plus a separator (2 spaces for easier readability)

does not exceed 128.

An input file to my weaving program must store all the information that a woven draft would supply. A casual user, with no background in weaving, might have difficulty in understanding how to structure this file. Some knowledge of handloom or powerloom operations might be sufficient to produce desired textures. Figure 6 provides an example of the input file structure. Line A of the input to the program contains the number of harnesses. Line B holds the number of treadles used on the loom. This number serves to determine the number of tieup description input lines which follow. For instance, if the user specifies that three treadles are to be used, there must be three lines following that number describing the treadle tieup. The treadles are referenced in the order in which they are described (treadle 1 is line B1, treadle 2 is line B2...). The first number on any treadle tieup line indicates how many harnesses are tied to one treadle. (Suppose B1 is given as a 2. The program is expecting two harnesses to be tied to treadle 1. These harnesses are described as c1 and c2). Descriptor C indicates the size of the repeat in the vertical yarns or warp. (The colors selected to represent the warp yarns are described as clr, clg, clb, for specifying an amount of red, green and blue... and the harness they are threaded through by harn1...) The weft colors or horizontal yarns are described in the next sequence. A repeat indicator, D, tells how many different colors are used. Dlr, dlg, dlb describe the colors in the weft yarn and Dl describes the number of times that color is repeated.

Finally, the size of the treading sequence for one repeat in the weft, E, is given followed by the treading sequence (e1, e2, e3).

A		number of harnesses
B		number of treadles
B1	c1 c2...	treadle 1
B2	d1 d2...	treadle 2
B3	e1 e2...	treadle 3
C		warp repeat size
c1r c1g c1b	harn1	color of harness 1
c2r c2g c2b	harn2	color of harness 2
c3r c3g c3b	harn3	color of harness 3
D		number of colors in the weft
d1r d1g d1b	D1	weft colors and repeat number
E		treadle sequence repeat size
e1 e2 e3 e4 e5...		treadle sequence

figure 6
diagramed input file for weaving program

4	number of harnesses
6	number of treadles
2 1 3	
1 1	
1 2	
1 3	
1 4	
2 2 4	
4	warp repeat size
.8 .4 .4 1	
0 .8 .4 2	
.8 .4 .4 3	
.8 .4 .4 4	
1	number of weft colors
.2 .2 .5 1	
6	treadle sequence repeat
1 2 3 4 3 2	

figure 7
input file for weaving program

The program is executed much like a weaver would weave the sample. The user is queried for the names of the input file, the background colors, the texture file name, and the skeleton draft output file name. The sample is then "woven" by examining the treadle tieups in the order specified by the treadle sequence. The entire 128 by 128 pattern matrix is initialized and loaded with the weft colors. The program uses the treadle tieup, treadle sequence, and the harness draw information from the input file to determine how to replace the pattern matrix locations with the warp colors to produce the pattern. The effect is that of a rising shed loom where the warp yarns are lifted and the weft yarns inserted underneath them.

The computer program is closely modeled after the methods used to generate a pattern weave draft by hand. My intent was to use standard or conventional drafting methodology to allow one who understands drafting conventions to use this program. Instead of supplying visual information to produce the draft, one needs only to supply the numerical information supplied in the harness draft, treadle tieup, and treadle sequence. The program will produce the diagram. It will also translate the diagram into a texture form for mapping onto a two and three dimensional surface.

The development of my program currently ends at the point of creating two dimensional woven texture patterns. This is due in part to time constraints and to my inability to write the sophisticated computer programs required by my original intent.

As mentioned earlier, I wanted the program to also work in reverse. That is, the designer would generate the shapes or designs, the program would analyze it and output sufficient information allowing a weaver or automated loom to weave the pattern or design. This would require the need for a system that allowed design and development to be accomplished through the use of painting, cutting and pasting on the computer. These tools need to be flexible enough to allow for both two and three dimensional modeling of a finished piece. Such tools would open up to the designer, possibilities for designs of large scale, two and three dimensional wall hangings, or single pattern repeat pieces such as coverlets of blankets.

I also envisioned a program that would utilize the three dimensional qualities in the yarn itself. Current weave programs deal only with a two dimensional model of a three dimensional fabric. Mathematical formulae may simulate lights and darks or the shading of the individual yarns in three dimensions. An ideal solution, however, might be the actual creation of the yarns in three dimensions with the qualities the designer chooses. These three dimensional yarns could in turn be used to weave the final fabric.

Generating-computer-aided design tools for a textile designing environment would open up new possibilities for the creation of fiber art pieces. The imagination would be rewarded immediately with a knowledge of what the piece would look like when completed, before its completion. Too often the designer's image, from the two dimensional model, is not adequately reflected in the actual look or feel

of the completed piece. Many hours of weaving could be spared. The weaver using these computer tools, need not wait until after the weaving process is complete, to understand if the yarns and fibers will interact as planned.

CHAPTER 4

Texture Mapping

The realistic representation of life like models is a problem facing researchers in the field of computer graphics. Scientists struggle to simulate human forms which move and act as the human figure does. Part of the credibility of representing the human environment is found in its tactile or textural elements.

A primary characteristic of a woven fabric is its tactile qualities. Human beings rely upon upholstery clothing, drapery, wall coverings, etc to make their lives more comfortable and familiar. Without these, a scene depicting human life, as we know it, seems unnatural. Researchers have discovered the need to display human forms in their familiar textural environment as prerequisite to the scene's credibility.

Data created by the computer to display objects is made up of points and polygons. When creating simple or complex graphical data using the computer, a series of points are given, along with a point list. This list describes how each of the points will connect to form a polygon. Groups of polygons make up a surface of an object. The computer calculates the object surface and displays it on the CRT.

Textures increase scene complexity and provide a low cost solution to modeling surfaces. They can eliminate the need to use many surfaces in describing detail. [9] The texture is synthetically

transferred or mapped onto the polygons by repeating the texture across a surface until the object is covered by the texture.

Paul MacDougal's algorithm for texture mapping was initially intended for use in simulating terrain from a distance. The texture is mapped onto the top and onto the bottom of the object. Colors at the edges of the texture are smeared along the side of the object to cover those surfaces. Another texture mapping solution available at CGRG was developed by Franklin Crow, formerly of Ohio State. Crow allowed for a more realistic modeling of a texture on objects. However, Crow's algorithm is effective only with objects created by a method called solids of revolution. Here a profile is generated and revolved around a maximum of three paths. I rarely used this method due to complexity and lack of cylindrical symmetry involved in most of the data I created during my research.

While MacDougal's algorithm eliminated many of the problems inherent in Crow's algorithms, MacDougal's algorithms created unwanted streaking on multi-sided objects. Most textiled objects are textured evenly around their surfaces and this streaking was unacceptable. My solution was to take the three dimensional objects and flatten all their polygons onto a two dimensional surface. I then mapped the texture onto this two dimensional surface (figure 8). Provided all the polygons are defined in the same order in the two dimensional object file as in the three dimensional object file, the two dimensional texture coordinate file created by MacDougal's texture mapping algorithms can be used to define the texture coordinates

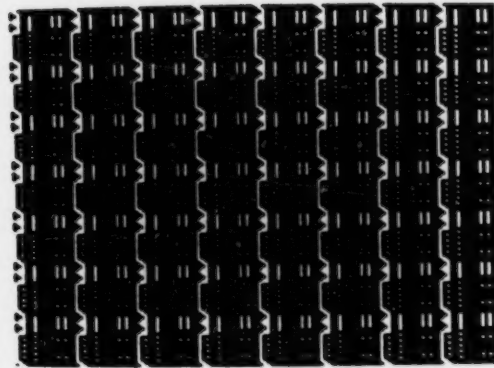


figure 8
computer generated woven texture sample

for the three dimensional object. In a sense it is like texturing a two dimensional, flat pattern and folding it up to become the three dimensional object (figure 9 & 10).

Another obstacle I encountered was the aliasing of a small woven texture onto a larger three dimensional surface. Aliasing, a problem encountered when trying to resolve a straight line on a diagonal, occurs when the individual pixel size is too large. The results in a stair-stepping or jagged effect.

As the texture is scaled down and modeled onto the object, it becomes less and less recognizable. Compounding the problem by making each point of color on the pattern smaller than one pixel, the texture on an object becomes less noticeable when it is placed into the

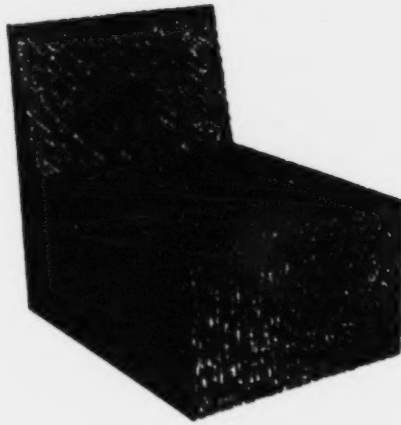


figure 9
computer generated woven sample mapped
onto a two dimensional object

screen space. The texture map no longer contains the repetitive qualities and subtle detail that the original pattern showed. Although I have labeled this a problem, it is similar to viewing a textured form from a distance and offers some advantages. The graphic display simulates the way the human eye naturally blends colors into one when viewing textures from a distance. Viewing a fabric sample close to ones eye allows one to inspect individual fibers and individual colors. However, this can be an undesirable way to choose an overall color effect. The further the object is in real space, the less recognizable the pattern of the fabric.

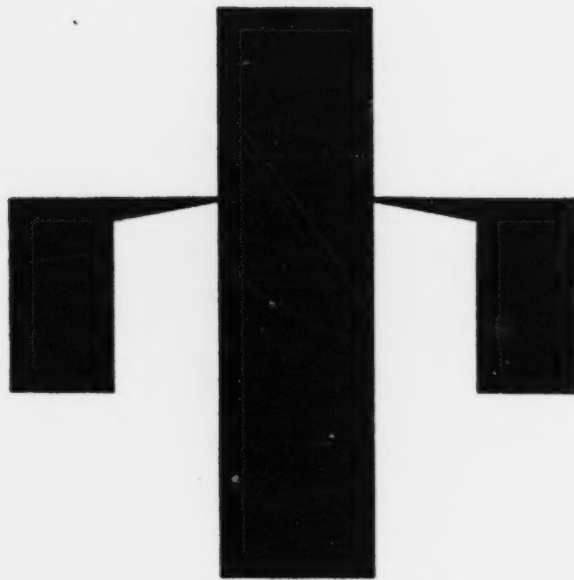


figure 10
computer generated woven mapped onto
a three dimensional object

There is no question that once the aliasing problem is better solved, textured objects will be more accurately represented in their transformed environment.

CHAPTER 5

Advantages and Disadvantages

The advantages of designing textile pattern weaves by my computer program will seem obvious to most weavers who have had even limited exposure to computers. The first and far most important advantage is the speed in which the designs can be generated. A color display of the weave can be generated in less than thirty seconds. This speed factor allows sketching, modification and refinement of the desired design.

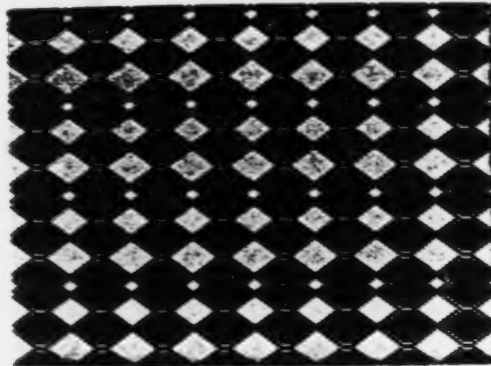


figure 11
example of a pattern weave using multiple pixel
rows to suggest one yarn. (yellow vertical stripes)

Small pixel size is an advantage when viewing a color simulation of a woven fabric. Structural necessities, such as alternating tabby weaves required by some fabrics but not intended to be viewed as part of the overall design, are barely recognizable in the color display of the fabric (figure 4). Multiple rows of pixels can be used to suggest a heavier yarn instead of allocating one vertical row of pixels to one color and harness (figure 11). Small pixel size becomes a disadvantage when trying to analyze a small section of the weave. However, the capability to print out, in a large black and white diagram, a draft of one repeat of the fabric is incorporated into my program (figure 12). This draft can be used in the final analysis of harness, treadle and pattern relationships.

The texture pattern one creates when using this weaving program also conforms to a CGRG standard for mapping the patterns onto three dimensionally defined objects. This permits the use of the textures in a three dimensionally simulated environment (figure 13).

draft for heart.drft
 number of treadles - 8 harnesses used - 10
 warp repeat size 16
 treadle sequence repeat size 14

harness draft	treadle tieup
X X X	X X X X
X X X X	X X X X
X	X X X
XX	X X X
X	X X X X
X	X X XX
X	X X X
X	X XXX
X	X X X
X	X XXXX

pattern	treadle sequence
X XXXXX X X X X	X
X X X X X X	X
X XXXX X X X X	X
X X X X X X X	X
X X XXX X X X X	X
X X X X X X X	X
X X X X X X X	X
X X X X X X X	X
X X X X X X X	X
X X XXX X X X X	X
X X X X X X X	X
X XXXX X X X X	X
X X X X X X X	X

figure 12
 computer generated black and white draft

cannot be accurately simulated using this particular method (figure 14). A process where two distinct layers of cloth are woven simultaneously, double weave produces a reversible fabric of two interwoven layers. Alternating shots of weft yarns are used to weave alternating surfaces of the fabric. The draft of a double weave shows

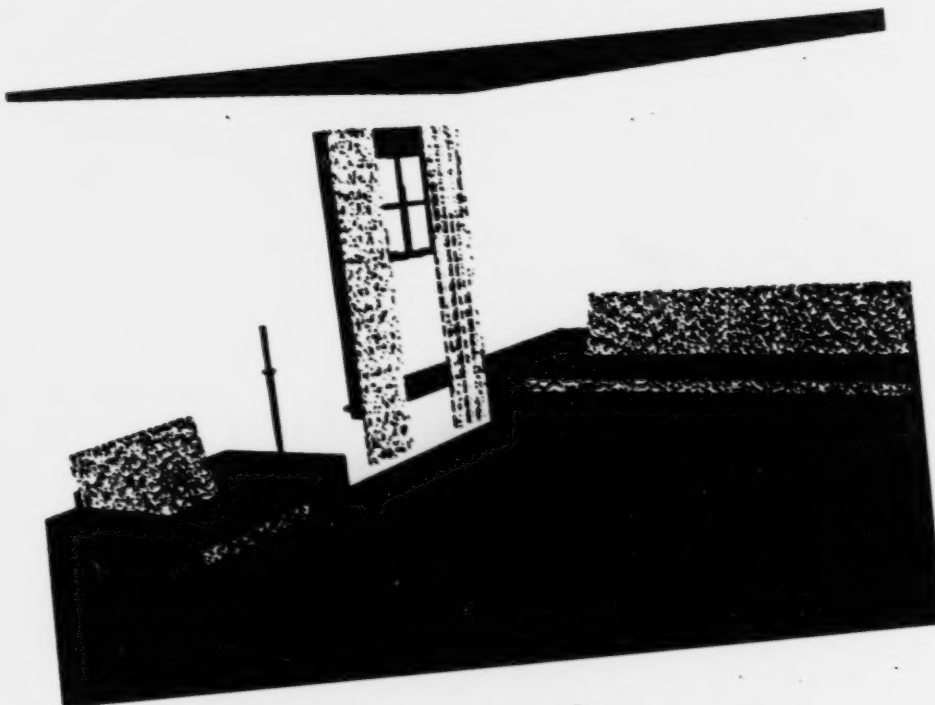


figure 13
room with texture mapped onto furniture

the alternating rows of the fabric as alternating rows on the draft.

Textures of a pile weave cannot be simulated using the computer method I employed. The generated sample from my program is a two dimensional representation of the woven fabric. The same is true for yarns that have thick and thin properties (slub yarns). My program depicts each yarn as being uniform in diameter. There is no allowance for irregularities in the yarn descriptions. Some tapestry techniques that involve looping and knotting of the weft yarns cannot be simulated using the program. Overall tapestry effects are also difficult to represent as a warp faced or weft faced fabric cannot be gen-

erated. The program is based exclusively on the assumption that woven fabrics are horizontal and vertical yarns interlaced at right angles to each other as found in pattern weaves.

Additional disadvantages appear due to restrictions determined by the program. Width and length of the texture map size limit the size of the pattern repeat. Many overshot patterns require many ends in the warp to complete a repeat. Often times this exceeds the 128 ends allowed by the program. To effectively view and analyze the design of an overshot draft, two repeats are needed to allow the designer to view the point where the two patterns meet.

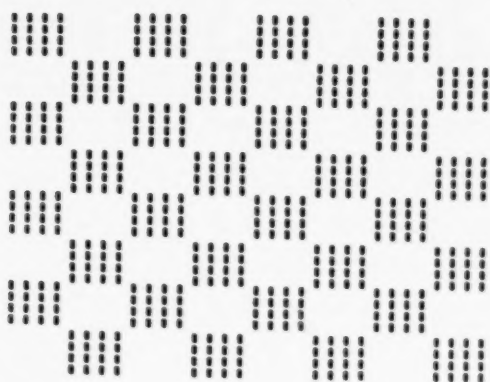


figure 14

A basket weave in brown and white. The white spaces are areas where a texture would be apparent on an actual woven fabric. They are not apparent at all in this computer generated sample.

For accurate repeating of the texture pattern it is necessary to make the edges of the texture cohere. The single repeat that makes up the pattern must be limited to a size that divides evenly into 128. Unfortunately there are limited number of factors of 128 and one repeat in the warp and weft of the pattern must conform to one of these sizes.

In conventional weaving, before the warp yarns are tied to the loom and tension applied, the yarns are threaded through a reed (figure 15). The reed is made up of a comb like structure and provides the means in which the yarns are kept separated from and horizontal to each other. The spaces in between the wire reed are called the dents. The reed can also be used to produce a striping effect. Several yarns are threaded through one dent in the reed. These yarns remain closer to each other as the fabric is woven than to the yarns in the neighboring dent. Lace or leno weaves can be woven using this method (figure 16). Computer drafted wovens use no reeds to produce the sample. The designer can only simulate this denting technique (figure 17).

By using the background color in the sample as a warp yarn color, the user threads the yarn through the identical harness of either neighbor. This is not an ideal solution since it only simulates the effect of multiple denting and doesn't achieve the same look the original fabric would have. If the open weave is to be modeled as a texture onto an object, the color of the object being mapped must be known in advance of the weave design. This is required

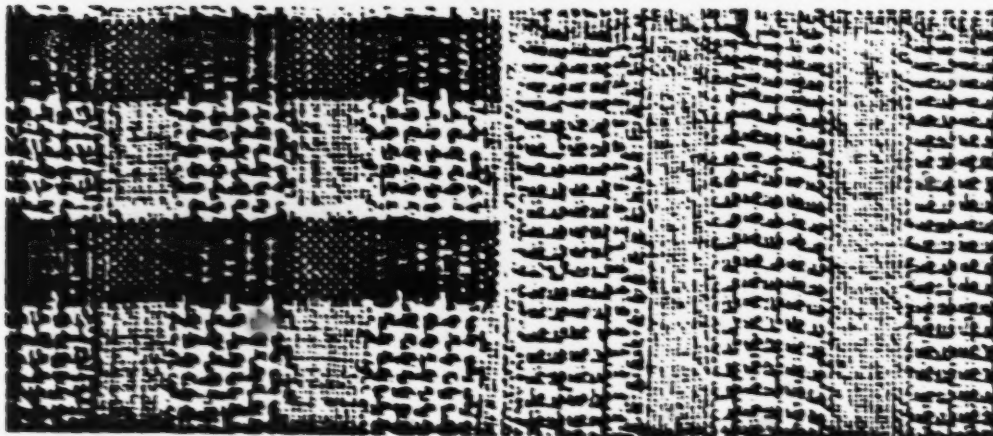


figure 16
handwoven lace sample

conventional method of drafting. However, existing software and hardware will accurately represent a woven sample and provide a user with features a conventional draft cannot.

CHAPTER 6

Educational and Industrial Applications

Drafting of the weave prior to the weaving of the fabric is of educational importance. In order to anticipate how a design might be completed, the student must be able to refer to sketches and other visual studies. This allows him or her the flexibility to refine and modify design choices that best convey the qualities of those ideas. [3] Traditional drafting methods tend to restrict the designer to an original concept of the design due to time constraints. As a result, changes in the treadle tieup, treadling sequence and draw through the harnesses are left to succeed or fail during the actual weaving process. Designs are more successful if they are thoroughly planned before the actual weaving has taken place. If a draft is not thoroughly complete, additional time is wasted in threading and rethreading the warp yarns and removing rows of weft yarns that produced an undesirable pattern. This results in a discouraging experience for the weaving student.

Since 1974, The Philadelphia College of Textiles and Science has been using a PDP 11/20 computer to implement a computer weaving program as a teaching tool. The weave is represented as a black and white draft of X's and -'s (dashes). The dashes representing the weft yarn on the surface of the fabric and X's representing the warp. Speed and freedom from the mechanics of hand drafting a design is seen as the major advantage in creating functional and aesthetically

appealing designs. [13]

Other weaving programs have been written to simulate and expedite the drafting process. Most of the computer programs developed were implemented on Apple computers. The Posneg program, a study project enacted by the Portland, Oregon Handweavers Guild to develop weave capabilities on microcomputers, used an Apple II. Their intention was to study possible effect of block design patterns, or patterns with foreground/background relationships. This program seems to be the most successful of all the documented programs. It stirred quite an interest within the weaving community of Portland and resulted in the development of more innovative pattern weaves. [10]

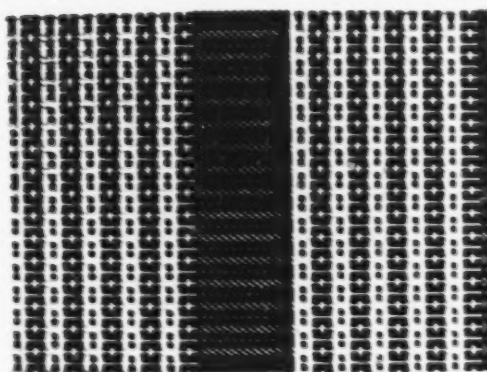


figure 17
computer generated lace sample

Industry can benefit from programs that simulate woven fabrics and map them onto computer generated objects. Industrially produced textiles require that designs be precise and uniform in order to be cost effective. The manufacturer has much to gain financially from such methods since hand drafting is the most time consuming step in the weaving process. Brintons Associated Weavers, a carpet design company in Bradford, England, had, by 1977, a computer system that would allow the designer to quickly change a carpet textile design during any stage in its development. A design can be repeated, reversed, contracted or elongated without painting a draft. Referred to as the Sci-Tek Response System, it was originally developed for aircraft movement by the Israelis. It has since been adapted to provide a design aid facility. Jobs that used to take six designers three weeks of work to produce color separations for each new color range, now take only an afternoon. [8] The basic design is scanned and stored into memory. When the design is to be used, the operator recalls the design and manipulates it on a monitor. The system will then scan the overall pattern and automatically separate the colors by tone and weight. [11] This efficiency step on the design phase leaves more time for the designers' original work. [7]

Another advantage for industry is found in the marketing of the design. If a buyer finds a pattern to be not quite suitable, a quick and accurate change can be made and the design shipped to the factory immediately. No extra days are wasted redrafting large patterns. Communication between the design studio and the factory can be

reduced to advanced telecommunications. The specifications can be sent accurately in minutes to a factory hundreds of miles away. On the receiving end, a printout can be handed to a loom threader and the weaving process begun. Alternatively, the electrical impulses sent by wire to the factory can be interpreted by a computerized threader and woven. Human interaction would be avoided and errors minimized.

Implementation of mechanized industrial equipment has already eliminated many inefficient means of knitting, weaving and printing textiles. Knitting machines and weaving looms have, in the past ten years, come to rely heavily on computer technology. Computers have made improvements in synthetic fiber development, quality control, color and dyeing methods, efficiencies of operations, efficient use of materials, a reduction in the finished work, and employee productivity. They are producing better quality products for the customers and a better value for the money. [7] Dyed fibers are now being monitored and reproduced more accurately than ever before. Unfortunately, the current economic climate in this country has lead manufacturers to limit research and development in these areas. They feel the reduced capabilities and cash flow will not permit the completion of the modernization process. Textile computer systems are, however, continuing development but at a substantially reduced rate and for short term goals. [12]

Yet little research and development seems to have been done to mechanize the designing process. As demonstrated by the Brintons

Associated Weavers Carpet Producers implementation of more computer controlled manufacturing tools, cheaper and better quality fabrics can be produced if a more versatile instruction set could be available for these machines.

CHAPTER 7

Summary

The cost of computer memory is radically declining. As a result, it is economically feasible for patterns to be stored and recalled, modified and displayed on color monitors or graphic printers before they leave the studio. With existing computer capabilities fabrics can be tested before they are woven to determine elasticity, durability and resiliency. Advances in the uses of specific pattern weaves can be researched and developed for their properties. Industrial fabrics can be designed for programs such as NASA, the defense department, firefighting and police. Additionally, fabric designs could be mapped onto three dimensional objects and used in preplanning fabric uses.

Presently, two dimensional color display devices and the software to accompany them are relatively inexpensive. This technology is getting cheaper and cheaper. Further, three dimensional graphic research and development will permit increasingly accurate visual renditions of a fabric. At present, this technology is expensive and requires a lot of time to generate a single display. Yet with contemporary technology, it is possible to design and modify a fabric more efficiently than with conventional drafting methods. Eventually this technology will become less expensive, faster and more accurate.



figure 18
computer generated weave sample used in creating the
wall covering and upholstery covering for figure 20.

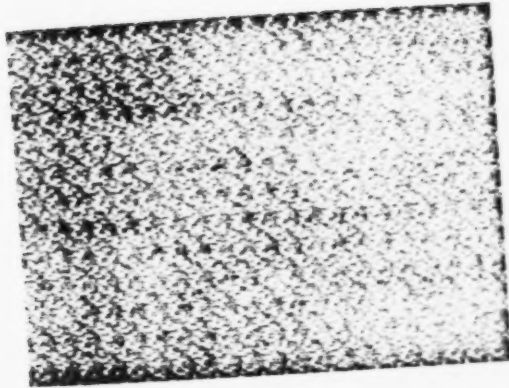


figure 19
computer generated weave sample used in
creating drapery in figure 20.

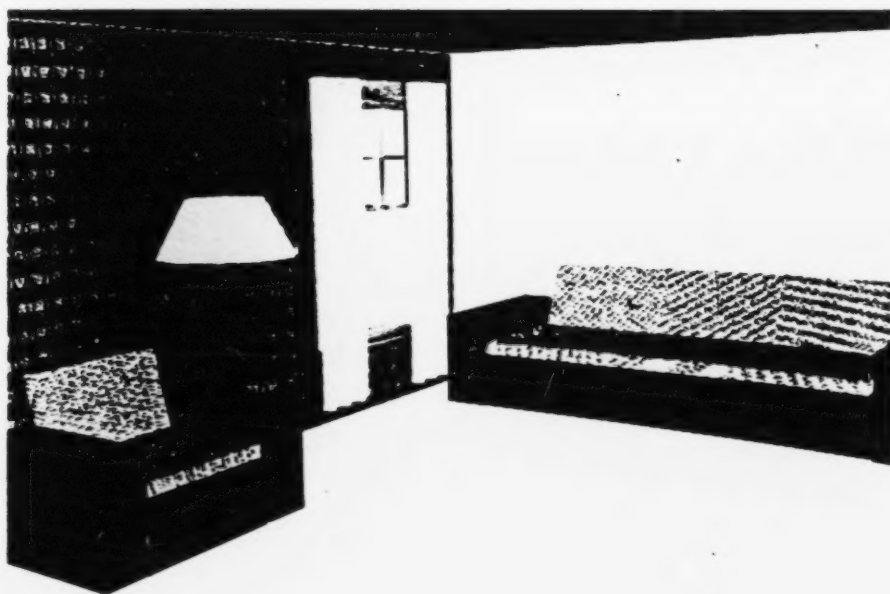


figure 20
scene using computer generated weave
samples in figure 18 and figure 19.

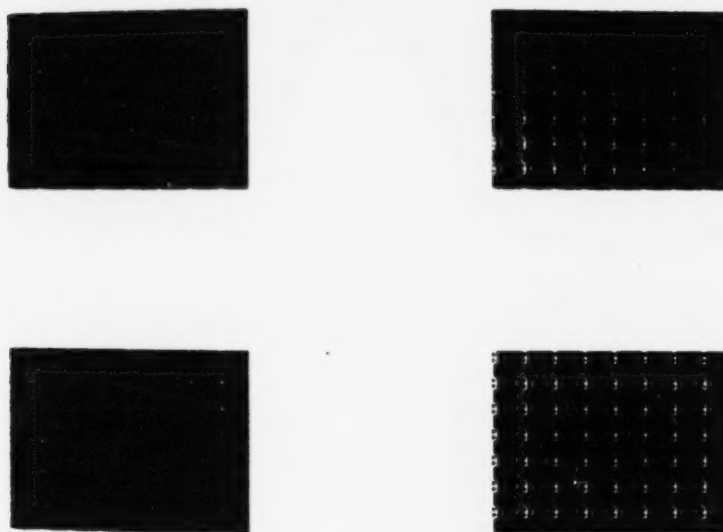


figure 21

A series of computer generated colorings of one pattern.
Colorings are merely different colors of one pattern
but must portray the same values or feeling associated
with the original sample.



figure 22
Additional samples of computer generated weaves.



figure 23
Computer generated variation on the shadow weave.



figure 24
Computer generated variation on the ripple weave.

Glossary

algorithm - an orderly list of instructions to the computer used for solving a problem, usually mathematical.

alphanumeric - a set of symbols consisting of both numeric and alphabetic characters.

bit - abbreviations for binary digit. The smallest unit of digital information. Represents either a 0 or a 1 or an on or off electrical signal.

buffer - a temporary storage area for information waiting to be processed by the main memory.

byte - a basic unit of information in the computer. Usually consists of 8 bits.

character - represented as one byte, a character is stored in the computer as a specific bit pattern and is usually a letter or a number.

chip - or a microprocessor, a chip is the heart of a microcomputer. A small piece of silicon in which thousands of electronic elements implanted.

CPU - stands for Central Processing Unit. The main section of a computer, it controls all of the processes of the computer.

CRT - Cathode Ray Tube. A television like device that permits the display of characters and graphic designs.

dent - reed is a set of wires on a frame. A dent is the space between the wires.

disk - a magnetic record like material that is used for storing information. Allows for random access of data.

disk drive - the hardware unit in which the disks are stored and which the disks are accessed.

execute - the running of the computer program.

filename - the name of a stored program or data file. Similar to a book or magazine article title.

four harnesses loom - a loom that houses four harnesses. Other types of looms are referred to as eight, sixteen, etc. harness looms.

hardware - the actual physical equipment that is used in the running of the computer. Disk drives, tape drives, printers, and circuits are

examples of hardware devices.

harness - a frame that supports a group of heddles on the loom.

harness draft - a sequence across the top of a drafted pattern design to indicate how warp yarns are threaded through the harnesses and heddles.

heddle - a wire, cloth or metal strip with an eye in the middle. Attached to the harness, the warp yarns are thread through for controlling the shed.

input - information being sent into the computer for processing.

jacquard - a complex power loom capable of producing elaborate pattern weaves.

lace - knotted, interlaced, interlooped or twisted yarns that form an open work fabric.

leno - a weave where warp yarns cross over each other instead of lying parallel to each other.

loom - any device for weaving that performs the minimum function of holding the warp yarns taut and in their proper position.

magnetic tape - a tape similar in appearance to a tape used for recording music. An inexpensive means of bulk storage of information. Ideal for transferring information from one computer to another.

main memory - The part of the computer that contains the operating system, computer programs and processes the data. The high speed memory.

memory - the section of the computer that stores information. More technically, the integrated circuit that stores information. (see also main memory)

microcomputer - a computer where one chip controls all the processes.

operating system - the managing programs of the computer. It typically controls the input and output functions of the computer.

pixel - a single unit on a raster display device.

programs - a set of instructions given to the computer to perform a task or solve a problem.

raster - a means of displaying graphic information. A raster display covers the screen with a rectangular grid or matrix of illuminated dots or pixels, each varying in value and intensity.

reed - keeps the warp yarns horizontal and beats the filling yarn into the fabric to keep them firm.

selvedge - the finished edges of the fabric.

shed - the space between the separated warp yarns which the weft yarn is passed. A shed is created by raising one or more harnesses or heddles.

software - the programs that are used by the computer. The material that is used by the computer that is not an actual physical element.

tape drive - the hardware device that houses the magnetic tape.

treadle - foot lever that controls the raising and lowering of the harnesses on a floor loom.

treadle sequence - the sequence in which the treadles are tied to the harnesses and the order in which they are pressed.

vector display - a device that allows for an image, usually a wire frame or a line drawing of the image to be displayed.

warp - a set of yarns that are parallel to each other and to the selvedge of the fabric. The vertical yarns of the fabric.

weft - a set of yarns or other materials perpendicular to the selvedge of the fabric. The crosswise element of the fabric.

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